Original Article

Investment Traits and Intelligence in Adulthood

Assessment and Associations

Sophie von Stumm

Department of Psychology, Goldsmiths University of London, London, UK

Abstract. Intelligence-as-knowledge in adulthood is influenced by individual differences in intelligence-as-process (i.e., fluid intelligence) *and* in personality traits that determine when, where, and how people invest their intelligence over time. Here, the relationship between two investment traits (i.e., Openness to Experience and Need for Cognition), intelligence-as-process and intelligence-as-knowledge, as assessed by a battery of crystallized intelligence tests and a new knowledge measure, was examined. The results showed that (1) both investment traits were positively associated with intelligence-as-knowledge; (2) this effect was stronger for Openness to Experience than for Need for Cognition; and (3) associations between investment and intelligence-as-knowledge reduced when adjusting for intelligence-as-process but remained mostly significant.

Keywords: intelligence, investment traits, knowledge, Need for Cognition, Openness to Experience

In his intelligence-as-*P*rocess, *P*ersonality, *I*nterests and intelligence-as-*K*nowledge (PPIK) model of intellectual development in adulthood, Ackerman (1996) suggested that intelligence-as-process, also referred to as fluid intelligence (i.e., the ability to solve novel problems), develops over time into intelligence-as-knowledge (i.e., a person's depth and breadth of knowledge). This development is guided by personality traits, in particular, so-called investment traits that determine when, where, and how people apply and invest their intelligence (Ackerman, 1996). The PPIK builds on earlier *investment theories* (e.g., Cattell, 1943; Hemnon, 1921), which have recently attracted much research interest (e.g., DeYoung, Grazioplene, & Peterson, 2012; von Stumm, Chamorro-Premuzic, & Ackerman, 2011; Ziegler, Danay, Heene, Asendorpf, & Bühner, 2012). However, to date, there is no consensus on how best to assess investment or intelligence-as-knowledge (von Stumm & Ackerman, in press).

Investment

Investment traits refer to "the tendency to seek out, engage in, enjoy, and continuously pursue opportunities for effortful cognitive activity" (von Stumm et al., 2011, p. 225). On the one hand, they are thought to explain interindividual differences in the pursuit of learning opportunities, such as visiting museums and galleries, solving riddles and puzzles, and reading newspapers (Soubelet & Salthouse, 2010; von Stumm, 2012). On the other hand, investment traits may contribute to constructing even mundane experiences in a cognitively stimulating manner, thereby enhancing intellectual development and growth (Kashdan, Rose, & Fincham, 2004; Stine-Morrow, 2007). An abundance of investment trait scales are scattered across the literature, but most frequently studied in this context are Need for Cognition (Cacioppo & Petty, 1982) and Openness to Experience from the Five Factor Approach (FFA; Costa & McCrae, 1992; McCrae, 1994).

The Need for Cognition scale assesses "differences among individuals in their tendency to engage in and enjoy thinking" (Cacioppo & Petty, 1982, p. 116). Accordingly, "Cognisers [. . .] naturally tend to seek, acquire, think about and reflect back on information" (Cacioppo, Petty, Feinstein, & Jarvis, 1996, p. 198), whereas "cognitive misers" rely to a greater extent on external advisors, cognitive heuristics and social comparison processes. Thus, the Need for Cognition scale narrowly assesses dispositions for cognitive engagement and thinking (Mussel, 2010). Conversely, Openness to Experience refers more broadly to "a preference for the new and different in many aspects of life" (McCrae, 1994, p. 257). The NEO-PI-R assessment spans six Openness facets of Fantasy (vivid imagination), Esthetics (appreciation for art), Feelings (perceptive to emotions), Actions (novelty seeking), Ideas (intellectual curiosity), and Values (readiness to challenge preconceived notions; Costa & McCrae, 1992). The shorter and commonly employed Openness NEO-FFI measure includes two items of each facet, forming a broad, comparatively undifferentiat-

DOI: 10.1027/1614-0001/a000101

ed dimension of open-mindedness (Costa & McCrae, 1992). As Need for Cognition and facets of Openness to Experience – in particular, Ideas – are positively correlated, they have been argued to assess the same construct space (Mussel, 2010; Fleischhauer, Enge, Brocke, Ullrich, Strobel, & Strobel, 2010). However, it is unclear to what extent the narrow Need for Cognition and the broad Openness to Experience measures differ in their association with intelligence-as-knowledge (see Wittmann & Suess, 1999).

Intelligence-as-Knowledge

While intelligence is traditionally assessed in terms of maximum performance (i.e., what a person *can* do), investment traits tend to measure typical performance (i.e., what person *will* or *prefers* to do; Cronbach, 1949; Fiske & Butler, 1963). In settings of low situational press (e.g., leisure time), individual differences in typical performance (e.g., time spent reading a novel) predict typical outcomes (e.g., knowledge of literature). In high situational press settings (e.g., at school), individual differences in maximum performance (e.g., reading speed) predict maximum outcomes (e.g., exam grade). However, when predictor and outcome variable follow different psychometric designs, validity coefficients can be expected to be considerably reduced (see Klehe & Anderson, 2007). While intelligence-as-knowledge comprises aspects of both typical and maximum performance, it is frequently assessed using maximum ability measures, such as timed crystallized ability tests for vocabulary or verbal fluency (Ackerman, 1996; Carroll, 1993). Not surprisingly then, individual differences in intelligence-as-knowledge are often attributed to variances in intelligence-as-process (Carroll, 1993; Cattell, 1971), rather than to typical performance variables, like investment traits.

Another issue with crystallized ability tests as measures of intelligence-as-knowledge is their scope, which is limited to consensus knowledge (Ackerman, 1996). By contrast, intelligence-as-knowledge is thought to cover a wide range of information and expertise, especially as learning experiences and subsequent knowledge become more and more differentiated with increasing age (Cattell, 1971). To accurately capture the breadth of intelligence-as-knowledge, its assessment should then entail aspects of academic study, active engagement in society (e.g., government functioning), occupational knowledge (e.g., specific skills and technical understanding), and knowledge associated with avocational hobbies (e.g., literature or music; Ackerman, 2000), in addition to crystallized intelligence measures.

The Current Study

The current study pursued two main aims. First, I included two measures of investment traits (i.e., Need for Cognition and a short version of Openness to Experience) to evaluate whether associations with intelligence-as-process and intelligence-as-knowledge were different for a scale that focuses specifically on intellectual engagement compared to a measure that broadly assessed open-mindedness. In this context, no explicit hypotheses were made, but the analyses were mainly exploratory. Second, a set of crystallized intelligence tests (e.g., vocabulary; McGrew, 2009) that are typically used in research were here complemented by a newly developed knowledge test that spanned 13 different knowledge domains (see details below) to comprehensively assess intelligence-as-knowledge. With regard to the knowledge test, it was predicted that (1) intelligence-as-process would be more strongly associated with crystallized intelligence than with knowledge; (2) crystallized intelligence and knowledge would be more strongly intercorrelated than their respective associations with intelligence-as-process were; (3) investment traits would be least associated with intelligence-as-process, moderately with crystallized intelligence, and most strongly with knowledge; and (4) the association of intelligence-as-knowledge with investment traits would remain sizeable after adjusting for intelligence-as-process.

Methods

Sample

A group of 200 British adults (97 men) was recruited for this study with an average age of 34.6 years (SD = 11.8; range from 18 to 69 years). As highest educational qualifications, 14% participants had completed GCSEs (10th grade); 15% A-levels (12th grade); 18% a vocational qualification or equivalent; 33.5% an undergraduate degree, and 19% a postgraduate degree. About half of the sample reported earning less than £15,000 ($22,500) per annum, while about 8% declared earning more than £35,000 ($52,000) per annum. Data from this sample study has also been reported elsewhere (von Stumm, 2012).

Measures

Fluid and crystallized intelligence were assessed with three tests each, including Raven's matrices (Raven, 1968), and five tests adapted from Ekstrom, French, and Harman (1976). The tests were selected in line with Carroll's (1993) and McGrew's (2009) reviews of the structure of human cognitive ability.

Fluid Intelligence

Raven's Progressive Matrices (Set E; Raven, 1968). Twelve items showed grids of 3 rows × 3 columns each with the lower right hand entry missing. Participants chose from

Table 1. Knowledge domains, their scope and example items

Domains	Focus	Items
Literature	Writers and works; literary styles and techniques.	How many lines does a sonnet consist of?
Science	Scientists and discoveries; mineralogy; chemistry; physics.	What metal is liquid at room temperature?
Medicine	Bodily functions and systems; human biology; disease.	What organ produces insulin?
Fashion	Clothing textiles and techniques; designers.	Which French designer popularized the 'little black dress'?
Sports	Sports (wo)men; sports games and rules; sports events.	Where will the Olympic games 2016 be held?
Economics	Finance theory, practice and events; world economy.	Who wrote "The Wealth of Nations," first published in 1776?
Music	Composers; music styles; instruments.	How many strings are on a typical guitar?
Politics	Basic principles of government; political events since 1850.	What peace treaty was signed after World War I?
Art	Art styles; artists and works; architecture; design.	Who designed 'the Gherkin' in London?
Geography	Countries and cities; deserts; oceans; populations.	What is the capital of Egypt?
Health and Food	Nutrition; food processing, sourcing and preparation.	What amount of beer equals one drink unit of alcohol?
Technology	Modern and historical technologies.	What are vehicles with two or more distinct power sources referred to?
Film	Film theory, content, and technique; actors; directors.	Who is "The Dude"?

eight alternatives the one that completed the 3 × 3 matrix figure. The test was timed at 4 min.

Lettersets: Participants identified the mismatching 4-letter set, inferring a rule underlying the composition of four other 4-letter sets. The test had 15 items and was timed at 6 min.

Nonsense syllogisms: Participants judged if a conclusion that followed two preceding statements (premises) showed good (correct) reasoning or not. The test had 15 items and was timed at 4 min.

Crystallized Intelligence

Verbal Reasoning: Participants identified the correct pair of words from a five options to complete a comparison sentence, whose first and last words were missing. The test had 14 items and was timed at 7 min.

Vocabulary: Participants identified the correct synonym for a given word out of five answer options. The test had 18 items and was timed at 4 min.

Verbal Fluency: Participants listed as many words as possible that started with one of two prefixes in 60 s.

Need for Cognition (Cacioppo & Petty, 1982)

Eighteen items measure the desire to engage in effortful cognitive activity on a 5-point Likert scale, ranging from *strongly disagree*, *disagree*, *somewhat agree*, *agree*, *strongly agree*. An example item reads: "I would prefer difficult to simple problems." Internal consistency typically ranges from .83 to .97 (Cacioppo et al., 1996).

Openness to Experience (NEO-FFI, Costa & McCrae, 1992)

Twelve items measure the tendency to for imagination, abstract thinking and esthetic awareness on a 5-point Likert scale, ranging from *strongly disagree*, *disagree*, *somewhat agree*, *agree*, to *strongly agree*. Internal consistencies approximate .80 across samples (Costa & McCrae, 1992).

Knowledge Test

Previous research (Irwing, Cammock, & Lynn, 2001; Rolfhus & Ackerman, 1999) and subject-matter experts[1] were consulted to identify knowledge domains that were (1) relevant to Western society, (2) of practical concern but could also be pursued for intellectual stimulation (e.g., current affairs in politics), and (3) conveyed by nonspecialist media. The very detailed previous work in this area, in particular by Rolfhus and Ackerman (1999), and the wide-ranging subject-matter experts' proficiency suggested that no additional advice was needed for the test development. Consensus between the subject-matter experts and the author was found for 13 knowledge domains, seven of which had also been assessed by previous researchers (Irwing al., 2001; Rolfhus & Ackerman, 1999). Overall, the scales were art, music, literature, geography, politics, history, finance, sports, fashion, film, medicine, science, food and health, and technology (Table 1). For each domain, up to 13 open-ended questions were developed with one- to two-word answers, including numbers, names (surnames sufficed), dates, and specific terms. Items were designed to cover one of five knowledge domain aspects: history (e.g.,

[1] The subject matter experts included a psychology professor, a quiz master, and an economics specialist. The complete test is available from the author upon request.

origins of a given subject); current state of affairs (e.g., people presently in representative functions; latest research); content (e.g., functionality; mechanisms); technique (e.g., definitions; application); and trivial knowledge about a given domain (e.g., celebrity news). Overall, 250 items were developed, whereby a first set of 119 items was administered to a convenience sample of 209 undergraduate students (43 males; M_{age} = 20.02 years, range 16 to 39, SD = 3.58), and a second, revised set of 131 items was tested in a convenience sample of 278 military officers (266 males; M_{age} = 39.12 years, range 29 to 50, SD = 3.57). The knowledge test data were evaluated using the indices of discrimination and of difficulty (Kline, 2000). The index of difficulty (ratio of correct versus incorrect answers) has recommended cutoff points of .20 and .80 for item probabilities (Kline, 2000), but because of the homogeneity of the samples, I chose cutoff points of .15 and .85. For the index of discrimination, point-biserial part-whole correlations were calculated between the individual items and the total scale score; items that correlated below .20 were excluded (Nunnally, 1978).

In total, almost 80 items had poor psychometric properties across both samples. They were discarded, and new items were developed to achieve comprehensive scales for each knowledge domain, resulting in a final test format with 120 items. The number of retained items per domain ranged from four to 11 with coefficient α values between .59 and .83. The unit-weighted composites of knowledge domains were by and large positively intercorrelated (Appendix, Tables A and B). In the student sample, an exploratory factor analysis with oblique rotation and parallel analysis (Monte-Carlo simulation; replications = 10,000) suggested extracting two higher-order factors, which was confirmed in the sample of military officers with domain scales loading .5 and above. One factor had loadings from politics, technology, science, literature, and geography, and the second factor comprised of fashion, art, sports, music, medicine, health, and film. Economics loaded on both factors. Thus, one factor represented mostly knowledge from *popular culture*, and the second knowledge from *academic disciplines*. The two factors will be herein referred to as academic and popular knowledge, which correlated at r = .68 in the student sample and at r = .83 in the military sample.

Procedure

Participants were recruited from the general population with online and flyer advertisement; no university students were recruited. Inclusion criteria were as follows: native English speakers, normal or corrected-to normal vision, hearing, and motor coordination, and having lived in the UK for at least 10 years. Participants were tested in 2-h sessions in groups of up to 20 in designated research laboratories under supervision. They took six intelligence tests in 40 min. After a short break, they then completed the knowledge test and finally personality and demographic questionnaires. All participants received monetary compensation.

Analysis

The z-scores of the intelligence tests were added to form unit-weighted composites of fluid and crystallized intelligence, respectively[2]. Also, unit-weighted knowledge domain composites were calculated, as well as summary scores for overall, popular knowledge, and academic knowledge. Next, correlations between intelligence, investment traits, and knowledge were computed, and a second series of partial correlations adjusted for fluid intelligence. To acknowledge the problem of multiple testing, I report the significance of the correlation coefficients at $p <$ .01; for comparison purposes, the reference p-value was also .01.

Results

Knowledge domains were positively intercorrelated with coefficients ranging from r = .41 to r = .82 (Appendix, Table C), and their higher-order factors of academic and popular knowledge were associated at r = .87 (Table 2). Fluid intelligence correlated with crystallized ability at r = .66 and with overall knowledge at r = .50. This difference in correlation coefficients was significant (Fisher's z = 2.42; p < .01). Knowledge factors and domains were more strongly associated with crystallized intelligence averaging at r = .65 than with fluid ability with an average of r = .41; again, this difference was significant (Fisher's z = 3.37; p < .001). Furthermore, knowledge and crystallized intelligence were significantly more intercorrelated than fluid intelligence was with either (Fisher's z = 4.92, p < .001, and Fisher's z = 2.51, p < .01, respectively).

Openness to Experience and Need for Cognition were intercorrelated at r = .54. Need for Cognition was moderately associated with fluid and crystallized intelligence and knowledge ($r \approx$ .35, in all cases). By contrast, Openness to Experience was less strongly linked to fluid intelligence (r = .35) than to crystallized ability (r = .52) and to knowledge (r = .48). Overall, Openness had an average correlation of r = .38 with knowledge domains and factors, compared to r = .29 for Need for Cognition. After adjusting for fluid intelligence, the association between crystallized intelli-

[2] The current results did not change when fluid and crystallized intelligence were operationalized as factor scores rather than as averaged composites.

Table 2. Correlations of fluid and crystallized intelligence, Openness, Need for Cognition, and age with knowledge factors and domains

	gf	gc	Openness	NFC	Age	gc[a]	Openness[a]	NFC[a]
gf	–				–.14			
gc	.66	–			.18	–		
Openness	.35	.52	–		.02	.40	–	
NFC	.34	.35	.54	–	.00	.18	.48	–
Knowledge	.50	.78	.48	.35	.16	.69	.38	.22
AK	.49	.78	.49	.35	.17	.69	.40	.22
PK	.46	.71	.40	.32	.13	.61	.28	.19
Arts	.49	.72	.53	.35	.19	.61	.44	.22
Film	.43	.62	.44	.28	.03	.49	.35	.15
Economics	.37	.60	.29	.22	.23	.51	.18	.11
Sports	.38	.57	.25	.20	.16	.46	.15	.08
Geography	.32	.59	.34	.23	.15	.53	.25	.14
Health & Food	.45	.70	.39	.28	.13	.60	.28	.15
Music	.40	.63	.45	.36	.12	.54	.38	.26
Literature	.41	.68	.48	.29	.12	.60	.40	.18
Medicine	.34	.63	.36	.28	.25	.58	.27	.19
Politics	.30	.60	.31	.28	.21	.56	.24	.20
Science	.53	.62	.45	.32	–.03	.43	.31	.17
Technology	.42	.54	.25	.26	.02	.39	.11	.13
Fashion	.42	.60	.42	.30	.07	.48	.35	.18

Notes. Correlations > .17 are significant at $p < .01$. Sample sizes vary between $N = 189$ and $N = 200$ after pairwise omission. gf = Fluid intelligence; gc = Crystallized intelligence; Knowledge = total knowledge test score; AK = Academic knowledge; PK = popular knowledge. [a]Partial correlations adjusted for fluid intelligence.

gence and knowledge reduced to $r = .69$ (Table 2). The correlations between Openness and knowledge domains remained largely significant but reduced in magnitude to an average of $r = .29$. Openness was now associated with crystallized intelligence at $r = .40$ and with overall knowledge at $r = .38$. Corresponding associations with Need for Cognition dropped to $r = .18$ and $r = .22$, respectively.

Discussion

The current study compared a narrow and a broad measure of investment (Need for Cognition and Openness to Experience) with regard to their associations with intelligence-as-process and intelligence-as-knowledge, as assessed by conventional crystallized ability tests and a new knowledge measure. Confirming the first hypothesis, fluid intelligence, which indicates an individual's maximum ability, was significantly more strongly associated with crystallized intelligence than with knowledge (see also Rolfhus & Ackerman, 1999). This difference is likely due to crystallized ability measures being slightly more representative of maximum than of typical performance, while for knowledge the reverse is true (Ackerman, 1996). In line with this, and confirming the second hypothesis, crystallized intelligence and knowledge were more strongly correlated with one another than fluid intelligence was with either.

Partially supporting the third hypothesis, Openness to Experience was more strongly associated with intelligence-as-knowledge than with intelligence-as-process, whereas Need for Cognition was linked to both with equal effect sizes. Thus, Openness to Experience may be more representative of an investment trait and less driven by individual differences in intelligence-as-process than Need for Cognition. Supporting this conclusion, as well as the fourth hypothesis, correlations between Openness to Experience and intelligence-as-knowledge reduced but remained significant after adjusting for intelligence-as-process. By contrast, the same associations with Need for Cognition became often nonsignificant. It therefore seems as if a narrow focused investment trait, like Need for Cognition, is more of a by-product of individual differences in intelligence-as-process rather than capturing open-mindedness or general intellectual curiosity. In this context, the current findings do not appear to be affected by a Brunswik asymmetry problem (Wittmann & Suess, 1999), which implies that differential associations of broad and narrow trait constructs with an outcome variable might be explained by the trait constructs' dissimilar level of abstraction. Here, the narrow Need for Cognition construct was equally strongly associated with narrow (i.e., crystallized intelligence) and broad measurements (i.e., knowledge) of intelligence-as-knowledge; the same was true for Openness to Experience. Thus, the findings are cannot be explained by differences in investment traits' levels of abstraction.

Knowledge Measure

In the two development samples, the new knowledge measure comprised two, highly intercorrelated factors identified as popular and academic knowledge. The popular factor was defined by domains like music, film, and sports, while domains such as economics, geography, and politics loaded onto the academic knowledge dimension. The two-factor structure differs from those of previous knowledge tests that suggested up to six underlying knowledge dimensions (e.g., Irwing et al., 2001; Beier & Ackerman, 2001; Ackerman & Rolfhus, 1999). The theoretical rationale in this study led to development of a knowledge measure independently of educational and professional qualifications or other achievement contexts, which is different to previous knowledge tests that tend to be based college or school curricula (e.g., Ackerman & Rolfhus, 1999; Rolfhus & Ackerman, 1999). In line with this, the currently established academic and popular knowledge domains are likely to refer to an elementary distinction in contemporary information perception. Indeed, they are somewhat reflected in the way in which daily newspapers are sectioned. That said, it is likely that a general factor of knowledge underlies both the popular and academic factor of knowledge, although such factor solutions were inadmissible in the current data[3].

Limitations

This study has some strengths, for example, its comprehensive set of measures, but it is also not without weaknesses – two in particular. First, and like most studies in this area (von Stumm et al., 2011; but see also Raine, Reynolds, Venables, & Mednik, 2002, and Ziegler et al., 2012, for a different approach), a cross-sectional research design was used, but only a longitudinal one allows drawing firm conclusions about the possible causal role of investment traits in adult intelligence. Second, the included investment traits (i.e., Openness to Experience and Need for Cognition) are self-report measures of behavioral tendencies (e.g., "I enjoy thinking") rather than a set of actual behaviors (e.g., "I read one book per week"). Indeed, it is unclear what type of behavior actually constitutes an *investment behavior*, which should be identified in future research (see von Stumm, 2012).

Conclusions

The current study introduced a new knowledge measure that compliments crystallized ability tests when assessing intelligence-as-knowledge. Furthermore, the NEO-FFI version of the Openness to Experience construct proved to be empirically more representative of an investment trait than the Need for Cognition scale. In particular, adjusting for intelligence-as-process reduced intelligence-as-knowledge associations with Need for Cognition to a greater extent than with Openness to Experience. Thus, the association between Need for Cognition and intelligence-as-knowledge seemed largely driven by individual differences in intelligence-as-process rather than in investment (see also Gow, Whiteman, Pattie, & Deary, 2005). It seems that being broadly open-minded is more conducive to intelligence-as-knowledge than having a narrowly focused tendency for intellectual engagement.

Acknowledgments

I thank Adrian Furnham and Eva Zoubek for their assistance with the data collection for this study.

References

Ackerman, P. L. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence, 22,* 227–257.

Ackerman, P. L. (2000). Domain-specific knowledge as the 'dark matter' of adult intelligence: gf/gc, personality and interest correlates. *Journal of Gerontology: Psychological Sciences, 55B*, 69–84.

Ackerman, P. L., & Rolfhus, E. L. (1999). The locus of adult intelligence: Knowledge, abilities, and nonability traits. *Psychology and Aging, 14*, 314–330.

Beier, M. E., & Ackerman, P. L. (2001). Current-events knowledge in adults: An investigation of age, intelligence and nonability determinants. *Psychology and Aging, 16*, 615–628.

Cacioppo J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology, 42*, 116–131.

Cacioppo, J. T., Petty, R. E., Feinstein J. A., & Jarvis, B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119*, 197–253.

Carroll, J. B. (1993). *Human cognitive abilities. A survey of factor-analytic studies.* Cambridge, UK: Cambridge University Press.

Cattell, R. B. (1943). The measurement of adult intelligence. *Psychological Bulletin, 40,* 153–193.

Cattell, R. B. (1971). *Abilities: Their structure, growth, and action.* New York: Houghton Mifflin.

Costa, P. T., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Cronbach, L. J. (1949). *Essentials of psychological testing*. New York: Harper.

DeYoung, C. G., Grazioplene, R. G., & Peterson, J. B. (2012). From madness to genius: The Openness/Intellect trait domain as a paradoxical simplex. *Journal of Research in Personality, 46*, 63–78.

Ekstrom, R. B., French, J. W., & Harman, H. H. (1976). *Manual for kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

Fiske, D. W., & Butler, J. M. (1963). The experimental conditions for measuring individual differences. *Educational and Psychological Measurement, 23,* 249–266.

Fleischhauer, M., Enge, S., Brocke, B., Strobel, A., & Strobel, A. (2010). Same or different? Clarifying the relationship of Need for Cognition to personality and intelligence. *Personality and Social Psychology Bulletin, 36,* 82–96.

Gow, A. J., Whiteman, M. C., Pattie, A., & Deary, I. J. (2005). The personality-intelligence interface: Insights from an aging cohort. *Personality and Individual Differences, 39,* 751–761.

Hemnon, V. A. C. (1921). Intelligence and its measurement. A Symposium – VIII. *Journal of Educational Psychology, 12,* 195–198.

Irwing, P., Cammock, T., & Lynn, R. (2001). Some evidence for the existence of a general factor of semantic memory and its components. *Personality and Individual Differences, 30,* 857–871.

Kashdan, T. B., Rose, P., & Fincham, F. D. (2004). Curiosity and exploration: Facilitating positive subjective experiences and personal growth opportunities. *Journal of Personality Assessment, 82*, 291–305.

Klehe, U., & Anderson, N. (2007). Working hard and working

[3] Details of higher-order factor analyses are not reported here, but can be requested from the author.

smart: Motivation and ability during typical and maximum performance. *Journal of Applied Psychology, 92,* 978–992.

Kline, P. (2000). *A primer in psychometrics*. London, UK: Free Association Books.

McCrae, R.R. (1994). Openness to experience: Expanding the boundaries of Factor V. *European Journal of Personality, 8,* 251–272.

McGrew, K. (2009). Editorial: CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research. *Intelligence, 37,* 1–10.

Mussel, P. (2010). Epistemic curiosity and related constructs: Lacking evidence of discriminant validity. *Personality and Individual Differences, 49*, 506–510.

Nunnally, J.C. (1978). *Psychometric theory*. New York: McGraw-Hill.

Raine, A., Reynolds, C., Venables, P.H., & Mednick, S.A. (2002). Stimulation seeking and intelligence: A prospective longitudinal study. *Journal of Personality and Social Psychology, 82*, 663–674.

Raven, J.C. (1968). *Progressive matrices: A perceptual test of intelligence*. London: H.K.

Rolfhus, E.L., & Ackerman, P.L. (1999). Assessing individual differences in knowledge: Knowledge structures and traits. *Journal of Educational Psychology, 91,* 511–526.

Soubelet, A., & Salthouse, T.A. (2010). The role of activity engagement in the relations between Openness/Intellect and cognition. *Personality and Individual Differences, 49,* 896–901.

Stine-Morrow, E. A.L. (2007). The Dumbledore hypothesis of cognitive aging. *Current Directions in Psychological Science, 16*, 300–304.

von Stumm, S. (2012). Investment trait, activity engagement, and age: Independent effects on cognitive ability. *Journal of Aging Research.* doi 10.1155/2012/949837

von Stumm, S., & Ackerman, P.L. (in press). Investment and intellect: A review and meta-analysis. *Psychological Bulletin*.

von Stumm, S., Chamorro-Premuzic, T., Ackerman, P.L. (2011). Revisiting intelligence-personality associations: Vindicating intellectual investment. In T. Chamorro-Premuzic, S. von Stumm, & A. Furnham (Eds.), *Handbook of individual differences*. Chichester, UK: Wiley-Blackwell.

Wittmann, W. W., & Suess, H.-M. (1999). Investigating the paths between working memory, intelligence, knowledge, and complex problem-solving performances via Brunswik symmetry. In P.L. Ackerman, P.C. Kyllonen, & R.D. Roberts (Eds.), *Learning and individual differences: Process, trait, and content determinants* (pp. 77–108). Washington, DC: American Psychological Association.

Ziegler, M., Danay, E., Heene, M., Asendorpf, J., & Bühner, M. (2012). Openness, fluid intelligence, and crystallized intelligence: Toward an integrative model. *Journal of Research in Personality, 46,* 173–183.

Accepted for publication: January 9, 2013
Published online: May 24, 2013

Sophie von Stumm

Department of Psychology
Goldsmiths University of London
New Cross
London SE14 6NW
UK
E-mail s.vonstumm@gold.ac.uk

Appendix

Table A. Correlations between domain knowledge scales in students (N = 209)

		n	α	1	2	3	4	5	6	7	8	9	10	11	12
1	Art	3	.25	–											
2	Film	2	.14	.39	–										
3	Economics	4	.35	.34	.33	–									
4	Sport	3	.30	.25	.28	.23	–								
5	Fashion	4	.57	.39	.27	.33	.30	–							
6	Geography	3	.37	.32	.25	.39	.35	.26	–						
7	Health & Food	7	.64	.30	.28	.34	.21	.35	.29	–					
8	Music	5	.52	.42	.33	.28	.32	.43	.31	.44	–				
9	Literature	4	.51	.41	.22	.36	.19	.22	.27	.41	.36	–			
10	Medicine	9	.69	.26	.28	.41	.25	.24	.29	.58	.32	.40	–		
11	Politics	2	.19	.27	.16	.37	.24	.27	.32	.23	.25	.42	.25	–	
12	Science	7	.63	.29	.34	.47	.23	.16	.30	.49	.32	.42	.59	.39	–
13	Technology	6	.65	.12	.25	.34	.18	–.05	.21	.40	.14	.40	.51	.34	.56

Notes. Health refers to health and food. Correlations above .21 are significant at $p < .001$. n is the number of items per domain. α refers to the coefficient α of internal consistency.

Table B. Correlation matrix of knowledge domains in military officers (N = 278)

	n	α	1	2	3	4	5	6	7	8	9	10	11	12
Literature	8	.82	–											
Medicine	11	.83	.76	–										
Economics	8	.60	.62	.65	–									
Music	9	.73	.73	.73	.54	–								
Politics	7	.62	.58	.56	.55	.51	–							
Fashion	6	.69	.73	.72	.58	.70	.50	–						
Sports	4	.77	.71	.76	.54	.69	.52	.68	–					
Art	11	.77	.80	.78	.66	.75	.61	.77	.69	–				
Technology	8	.60	.52	.62	.56	.55	.54	.49	.55	.61	–			
Film	11	.78	.75	.71	.56	.72	.58	.71	.65	.75	.56	–		
Science	10	.77	.66	.72	.56	.64	.57	.60	.62	.68	.71	.70	–	
Health & Food	10	.83	.78	.82	.62	.70	.51	.69	.73	.75	.52	.66	.67	–
Geography	8	.59	.54	.51	.52	.49	.57	.50	.48	.57	.54	.51	.60	.53

Notes. All coefficients are significant at $p < .001$. n is the number of items per domain. α refers to the coefficient α of internal consistency.

Table C. Intercorrelations of knowledge domain scales in a sample of British adults (N = 200)

		n	α	1	2	3	4	5	6	7	8	9	10	11	12
1	Arts	11	.79	–											
2	Film	11	.78	.72	–										
3	Economics	8	.62	.59	.49	–									
4	Sports	6	.68	.60	.64	.59	–								
5	Geography	11	.75	.68	.61	.63	.61	–							
6	Health & Food	11	.75	.70	.57	.62	.59	.64	–						
7	Music	8	.73	.77	.72	.59	.66	.66	.67	–					
8	Literature	9	.82	.77	.80	.55	.64	.68	.61	.75	–				
9	Medicine	11	.79	.68	.59	.60	.61	.60	.76	.64	.62	–			
10	Politics	9	.80	.66	.70	.62	.68	.74	.59	.67	.71	.65	–		
11	Science	10	.79	.67	.57	.58	.53	.64	.62	.58	.54	.61	.61	–	
12	Technology	9	.67	.58	.51	.58	.52	.61	.63	.55	.48	.58	.55	.64	–
13	Fashion	6	.68	.72	.68	.49	.56	.57	.67	.75	.71	.66	.60	.51	.41

Notes. All coefficients are significant at $p < .001$. n is the number of items per domain. α refers to the coefficient α of internal consistency.